Metamorphism and Deformation in the Variscan Foreland: Isotopic and Structural Evidence from the Wolsztyn-Leszno Phyllites, Wielkopolska, Poland

Andrzej ŻELAŹNIEWICZ[1], Dirk MARHEINE[2] and Teresa OBERC-DZIEDZIC[3]

[1] *Instytut Nauk Geologicznych PAN, Podwale 75, 50-449 Wrocław, Poland*
[2] *Laboratoire de Géochronologie, Université Montpellier 2, Montepellier cedex 5, France*
[3] *Instytut Nauk Geologicznych, Uniwersytet Wrocławski, pl. M. Borna 9, 50-204 Wrocław, Poland*

A Variscan foreland in western Poland comprises two NW-trending basement highs which are concealed under Carboniferous through Triassic strata of the Fore-Sudetic Monocline (FSM). Both highs consist of multiply deformed quartz-sericite ± albite ± chlorite phyllites, at least in part of volcanogenic origin. In the northeasterly situated Wolsztyn-Leszno High (WLH) such multiply deformed phyllites were drilled in 7 boreholes over 30 years ago by the petroleum industry. However, both protolith and metamorphic age as well as structural position of the phyllites have been unknown. Therefore, we attempt to shed more light on these problems which are important for understanding the evolution of the central European Variscides (Żelaźniewicz, et al. 2003).

A core from the Święciechowa 1 borehole was sampled for Ar-Ar dating of the WLH phyllites. They are covered by upper Viséan-Namurian A flysch (Górecka et al., 1977) and possess S_1 foliation moderately to steeply dipping and involved into asymmetric F_2 folds with shallowly dipping axial-plane foliation S_2. The latter is marked by rotated and recrystallized white mica forming up to 0.5 mm thick sericite layers, with persistent kinematics inferred from S-C structures. The S_2 shear planes intersecting the opposite limbs of the mesoscopic F_2 folds record the same sense of movement. This suggests that the shearing with thrust displacements of the hanging walls overprinted folding. The spatial distribution of the steep and shallow attitudes of the S_1 planes in boreholes, although inferred from scarce drillcores and log data, allow to infer that an overall structure of the WLH is that of a large-scale overturned fold related to thrusting. Direction of thrusting remains unknown because the drillcores were not orientated. However, subcrop outline and gravimetric data show that the WLH stretches NW-SE. The dipmeter data for boreholes penetrating Carboniferous successions on either limb of the WLH document SW-ward dips of Upper Viséan-Lower Namurian flysch beds (unpublished petroleum industry data). Accordingly, NW-trending structural grain of the phyllites and similar SW-ward regional dip of their foliations are supposed. Combining all these data with a minute stretching lineation of quartz (L_{2q}) present on the S_2 foliation planes, which matches the dip- to oblique-slip motion, it is inferred the studied Święciechowa borehole drilled the inverted fold limb of a large-scale fold overprinted by thrusting with top-to-the N kinematics. It is the very limb that was sampled for the Ar-Ar age determination.

The sample for analyses was prepared in the way permitting to measure isotopic ratios for the sericite flakes forming the S_2 layers. Since most of the measured isotopic ratios are very similar yielding ages between 346 and 337 Ma, we assume that all the dated sericites grew inside the S_2 layer, and the S_1 micas could hardly escape resetting.The dated sericites are estimated to have grown below or close to the blocking temperature of argon in white mica (350 ± 50 °C). Therefore, the growth ages of the S_2 synkinematic micas and the age of the F_2 folding and development of the S_2 foliation has most probably been obtained. Taking into account the error in estimation of temperature conditions during D_1 and D_2 which is within the same limit and because of good structural constraint on the studied S_2 mica layer, we suggest that the obtained age of 340.1 ± 2.6 Ma dates the lower greenschist facies metamorphism and most probably refers to the D_2 folding and shearing rather than to poorly constrained D_1 event, or to post-D_2 cooling.

The results of this study allow to suggest that in earliest Viséan times the pre-Viséan basement rocks of the Variscan foreland basin between the Odra Fault Zone and the Dolsk Fault Zone underwent large-scale, N/NE-vergent folding under the low greenschist facies conditions and by consecutive thrusting were transported away from the inner part of the orogen over the distance of some tens of kilometres and eventually brought to the surface on the listric faults in the hinge regions of major thrust-related folds. These folds form now the two observed phyllitic highs of Bielawy-Trzebnica and Wolsztyn-Leszno, which probably controlled the late Viséan through Permian topography and shed clasts to two foreland sequences of late Viséan-Namurian A age and Westphalian B-C age, respectively (Kłapciński and Lorenc, 1984; Żelichowski 1983, 1995). The upper Carboniferous strata were only britllely deformed, in a thin-skinned fashion, by folding thrusting and normal faulting in post-Westphalian C times.

References

GÓRECKA T., JUROSZEK C., KARWOWSKI L., KŁAPCIŃSKI J., LORENC S., MIERZEJEWSKI M., SACHANBIŃSKI M. and ŚLUSARCZYK S., 1977. Utwory skalne podłoża permu zachodniej części monokliny przedsudeckiej i perykliny Żar oraz przyległej części bloku przedsudeckiego. *Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej*, 22: 3–92.

KLAPCINSKI J. and LORENC S., 1984. Osady karbonu na południe od Poznania. Carboniferous sediments S of Poznań. Acta Universitatis Wratislaviensis. *Prace Geologiczno-Mineralogiczne*, 9: 19–33.

ŻELAŹNIEWICZ A., MARHEINE D. and OBERC-DZIEDZIC T., 2003. A Late Tournaisian synmetamorphic fold-

ing and thrusting event in the eastern Variscan foreland: $^{40}Ar/^{39}Ar$ evidence from the phyllites of the Wolsztyn-Leszno High, western Poland. *International Journal of Earth Sciences*, (in presss).

ŻELICHOWSKI A., 1983. Lithological associations in the Carboniferous in Poland. *Przegląd Geologiczny*, 6: 342–350.

ŻELICHOWSKI A., 1995. Occurrence of Carboniferous rocks and palaeotectonic conditions of sedimentation in the area of Poland – Western Pomerania and central Poland. In: A. ZDANOWSKI and H. ŻAKOWA H. (Editors), The Carboniferous System in Poland. *Prace Instytutu Geologicznego*, 147: 14–17.

Morphotectonic Properties Of Young Active Strike-slip Faults In Northern Vietnam

Witold ZUCHIEWICZ[1] and Nguyen Quoc CUONG[2]

[1] *Institute of Geological Sciences, Jagiellonian University, Oleandry 2A, 30063 Kraków, Poland; Galicia T. Group*
[2] *Institute of Geological Sciences, Polish Academy of Sciences, Research Center in Kraków, Senacka 1, 31-002 Kraków, Poland; Galicia T. Group*

The Red River (RR) and Dien Bien Phu (DBP) faults are conjugate strike-slip faults which in Pliocene-Quaternary times have shown, respectively, right-lateral and left-lateral sense of motion. The RR marks the boundary between the South China and Indochina blocks which has been shaped in two phases: during sinistral ductile shear active in 27–16 Ma, followed by exhumation and uplift from a depth of 20–25 km, and as dextral, predominantly brittle shear active in Plio-Quaternary times (Leloup et al., 1995 and references therein). This change of the sense of motion is related to collision between India and Eurasia. The pre-Pliocene history of the DBP is poorly known, although its recent sinistral character is obvious. Both these zones display different style of seismicity: RR is seldom accompanied by strong earthquakes, the strongest event recorded in historical times being 5.9, whereas DBP is the locus of frequent and relatively strong earthquakes of magnitudes 5–6 (max Ms 6.8). Geodetic (GPS) data are available for the RR only, showing 1–5 mm/yr of dextral slip (Cong and Feigl, 1999).

Indicators of recent strike-slip along the RR and DBP fault segments in Northern Vietnam include drainage offset and deflection (10–50 m to some 3.5 km along RR, and 6–50 m to 2–2.5 km along DBP), beheaded streams, shutter ridges, en echelon orientated minor fault and fault-line scarps, displaced terraces and alluvial fans, rectilinear fault valleys and long, rectilinear fault scarps. Moreover, the SE and northern portions of, respectively, RR and DBP faults, display increasing component of normal slip, as testified to by well-preserved triangular facets on fault scarps, highly elevated straths in river gorges, and overhanging valleys. The NW-SE – trending RR fault trace is accompanied by narrow pull-apart basins and grabens filled with thick Neogene terrestrial strata and relatively thin Quaternary sediments. Clasts in Neogene conglomerates are comonly fractured, indicating at least six phases of brittle deformation, alternately extensional and compressive ones. Clasts in Quaternary alluvium are, in turn, not fractured. On the other hand, the N to NNE trending DBP fault is accompanied by pull-apart basins whose size increases southwards and which are filled by Quaternary fluvial sediments, resting on Palaeozoic-Mesozoic bedrock. These sediments are frequently faulted and, at least in the Dien Bien Phu Basin, clasts composing alluvial fans are fractured parallel to the fault trace.

Our morphotectonic studies conducted in the medial segment of RR indicate 1–2 mm/yr of dextral slip and at least 0.1 mm/yr of uplift during the past 1–2 Ma (Cuong and Zuchiewicz, 2001). Morphotectonic indicators and displaced Quaternary alluvial sediments indicate that sinistral and sinistral-normal faults bounding pull-apart basins in the southern portion of the DBP appear to reveal minimum rates of sinistral strike-slip ranging from 0.6 to 2 mm/yr in Holocene and 2 to 4 mm/yr in middle-late Pleistocene times, whereas rates of Holocene uplift tend to increase northwards along the fault, from 0.4–0.6 to ca. 1 mm/yr. Long-term, average Quaternary uplift rates have certainly exceeded 0.05 mm/yr. Both the RR and DBP faults are capable of generating strong earthquakes in the future, particularly in the southern segment of DBP and SE segment of RR.

References

CONG D. C. and FEIGL K. L., 1999. Geodetic measurement of horizontal strain across the Red River Fault near Thac Ba, Vietnam, 1963-1994. *J. Geod.*, 73: 298-310.

CUONG N. Q. and ZUCHIEWICZ W. A., 2001. Morphotectonic properties of the Lo River Fault near Tam Dao in North Vietnam. *Natural Hazards and Earth System Sciences*, 1: 15-22.

LELOUP P.H., LACASSIN R., TAPPONNIER P., SCHAERER U., ZHONG D., LIU X., ZHANG L., JI S. and TRINH P.T., 1995. The Ailao Shan – Red River shear zone (Yunnan, China), Tertiary transform boundary of Indochina. *Tectonophysics*, 251: 3-84.